MINISTRY OF THE ENVIRONMENT

METRICATION GUIDELINES

FOR

CONSULTING ENGINEERS

ISSUED BY

MINISTRY OF THE ENVIRONMENT
METRIC COMMITTEE

FEBRUARY 1977

PREFACE

In view of the planned conversion from the traditional Imperial system of measurement to the metric system in all sectors of the Canadian economy, the Ontario Ministry of the Environment considered it desirable to issue to the Consulting Engineering profession in Ontario guidelines on metrication as it applies to the design and construction of water, waste water and resource recovery works.

This "Metrication Guidelines for Consulting Engineers" consists of material from a number of sources and reflects the Ministry's approach to the metrication process at the present time.

As time passes, additions, deletions or corrections will no doubt be necessary in the content of the Guidelines. The manual has been bound in such a form as to facilitate the removal of superseded pages and the insertion of the new pages.

We would welcome your comments.

K. H. Sharpe, P. Eng.,
Chairman,
Ministry of the Environment
Metric Committee.

February 1977.

MINISTRY OF THE ENVIRONMENT

Metrication Guidelines for Consulting Engineers

SECTION 1

INTRODUCTION

GUIDELINES FOR METRICATION

SECTION I - INTRODUCTION

In February 1976 the Intergovernmental Design and Construction Committee unanimously adopted the following:

Resolution

Whereas the Metric Commission has now formally accepted the metric conversion plan of the construction industry to adopt January 1, 1978, as construction M-day, i.e. the day after which most tenders will be called substantially in metric terms; and

Whereas manufacturers have confirmed that they will supply those hard converted metric materials and components considered to be essential to a meaningful M-day; and

Whereas other metric materials and components will become increasingly available after January 1978; and

Whereas the Standards Writing Organizations have confirmed that they will complete the metric conversion of priority standards by forecasted dates; and

Whereas metric supplements to the 1977 National Building Code will be published by May 1, 1977; and

Whereas metric design aid literature will become available in the Spring of 1976 and metric technical data on materials will become available from the Fall of 1976; and

Whereas conversion timetables for Federal, Provincial and Municipal activities have been defined; and

Whereas the construction industry is basic to the national economy:

<u>Be it Resolved That</u>:

The construction agencies of Federal, Provincial and Territorial Governments actively support the construction industry in its efforts to improve its effectiveness by:

1. Reviewing their construction programs with the objective of "capturing" as many new building projects as possible for metric tender calls after January 1, 1978.
2. By developing the preliminary designs for any such metric projects generated after May 1, 1976, on a rationalized metric grid, in order to facilitate transportation into working drawings in 1977.
3. By avoiding metric tender calls before January 1, 1978, to the fullest extent possible in order to maximize the benefits of a co-ordinated conversion program.

On August 25, 1976, the annual Intergovernmental Conference of Ministers and Deputy Ministers of Public Works, Government Services and Supply and Services unanimously resolved to actively support the metric conversion plans of the construction industry by capturing as many new projects as possible for metric tender calls after January 1, 1978.

MOE Guideline

All new MOE construction projects scheduled for tender after 1977 will use metric measurements and materials in accordance with the SI conversion plans set out by the Construction Industry.

The decision to go metric means:

- Site and building construction will be carried on using SI dimensions and, as far as possible, materials designed and built to the latest Canadian Standards Association (CSA) standards for metric modular construction.
- All instrumentation and control devices will be specified to have scales and control settings calibrated in accordance with the appropriate standards for preferred metric units of measurement.
- Design of plant process systems will be carried out in SI units wherever practicable and the design specifics for the purchase of process equipment will be in metric terms.

Much of the equipment and materials required for the plant process systems will not meet SI standards immediately. MOE's aim, however, is to encourage suppliers to provide such equipment as soon as possible, but not to force them into design changes before they reasonably may be made using new basic metric materials.

METRIC CONVERSION

General

The actual act of metric conversion can take two basic forms:

"soft conversion" - defined as "a change of measurement language to SI units, which may include physical changes not exceeding those permitted by former measurement tolerances", and

"hard conversion" - defined as "a change of measurement language to SI units, which necessitates physical changes outside those permitted by former measurement tolerances".

Soft Conversion

In "soft conversion" the actual dimensions of a product (or, for example, of a set-back distance, floor area, etc.) are not changed but are only expressed in appropriate SI units. Inevitably in most practical cases, when a "workable number" is required a certain "rounding off" of the calculated figure will be involved. Here common sense, practice and technical knowledge will come into play. The intention is to convey the degree of precision implicit in the original dimension, therefore a decision on the appropriate number of digits to be retained is necessary prior to rounding off the result of calculation. As an example let us assume that by exact calculation using conversion factors from Part 8, (Manual on Metric Building Drawing Practice), the resulting figure has more digits than required. Then the procedure is as follows:

a) when the first digit discarded is less than five, the last digit retained should not be changed, e.g. -

7.151 426 rounded to 4 digits -- 7.151;

b) when the first digit discarded is greater than five, or if it is a five followed by at least one digit other than zero, the last digit retained should be increased by one unit, e.g. -

3.416 72 rounded to 4 digits -- 3.417

2.213 501 rounded to 4 digits -- 2.214;

c) when the first digit discarded is five, followed only by zero, the last digit retained should be increased by one if it is odd, but no adjustment made if it is an even number, e.g. -

2.35 rounded to 2 digits -- 2.4

2.45 rounded to 2 digits -- 2.4

It must again be stressed that the most accurate equivalents in conversion are obtained by multiplying the quantity to be converted by the/appropriate conversion factor and only then, rounding the product. If the equivalent is obtained by first rounding the conversion factor to the same number of significant digits as in the quantity being converted, the calculation will most probably not be precise.

Hard Conversion

With very few exceptions, hard conversion to metric, as defined, involves a physical change (as may happen in the case of products originally manufactured to metric dimensions and up to now described in imperial units of measurement only for convenience). As far as manufactured goods are concerned, the change to metric dimensions offers in many instances an opportunity to rationalize product lines. For the construction industry this may lead to dimensional standardization of units and components. Advantages of this spin-off

of metric conversion are numerous and can only improve the economy of the industry.

These changes of course will not occur by a mere wish or by an isolated decision. Canadian standards-writing organizations, e.g. CSA and CGSB, are at present involved in the standards conversion program. Thousands of industry representatives are contributing their knowledge and time serving voluntarily on standards-writing committees. Many standards written in SI units will be prepared before M-day; the rest will be converted as quickly as possible and as required.

It is expected that various professional organizations and industrial sectors will make available design tools specifically for their field of work. The Intergovernmental Committee on Design and Construction has begun to issue bulletins indicating preferred dimensions of building components.

Metric Conversion of the 1977 Edition of the National Building Code

The Associate Committee on the National Building Code established at its meeting in November 1975 the following approach to metric conversion of the 1977 edition of the National Building Code, which will be published in January 1977.

1. The 1977 edition of the NBC will maintain imperial values as the official system of units with equivalent metric values (soft conversion) in brackets including duplicate tables where necessary to cover the soft conversion of tabular values.
2. Metric equivalents will not be given for dimensions relating to wood products nor for nominal product dimensions.

3. The Code will be supported by metric product bulletins to be issued at intervals to accommodate the introduction of metric products as they become available and these will apply to all parts of the Code.
4. All parts of the Code are to be converted to hard metric values to the maximum extent possible and issued as metric supplements by May 1, 1977.

Metric Conversion of the 1977 Edition of the Ontario Building Code

The present status of the National Building Code is as set out below in an excerpt from Public Works Canada Metric Bulletin SI-6.

1.1 The 1977 edition of the National Building Code will be published simultaneously in both official languages in July 1977. This edition of the code will use the customary or imperial system of measurement and will not provide any metric equivalents.

1.2 Metric values for all dimensions referred to in the code will be provided in a separate pamphlet giving either soft converted metric equivalents or hard metric values as appropriate. This metric pamphlet will be automatically distributed with each copy of the code.

1.3 During the transition period, Metric Products Bulletins will be issued at intervals to accommodate the acceptance of metric products within code requirements.

1.4 Preliminary copies of the 1977 edition of the National Building Code will be made available to Federal and Provincial design and construction agencies in January 1977. Preliminary copies of the metric pamphlet will be issued in April 1977.

1.5 The 1979 edition of the National Building Code will be produced as a wholly metric code.

Provinces which have a Provincial Building Code would require six to nine months following issue of the NBC to produce their

respective Building Codes.

The NBC without the metric has to be reviewed and three or four months later the metric supplements must be reviewed. It is a double review process.

The Ministry of Consumer and Commercial Relations expects to issue the OBC with hard conversions wherever possible before the end of 1977. However, this could change because the actual date of issue and the extent of hard metric conversion are dependent on two factors: (1) the availability of NBC with hard metric conversions and (2) the availability of the referenced standards with hard metric conversions.

The above approach is intended to accommodate the implementation of metric conversion in the construction industry in phase with the "M" day of 1 January 1978 and at the same time ensure that the Code is capable of practical application as a set of minimum legal requirements for building safety during the transitional stage of metric conversion when both imperial and metric size products are likely to be available.

SECTION 2

MAP AND PLAN SCALES, RATIOS AND PAPER SIZES

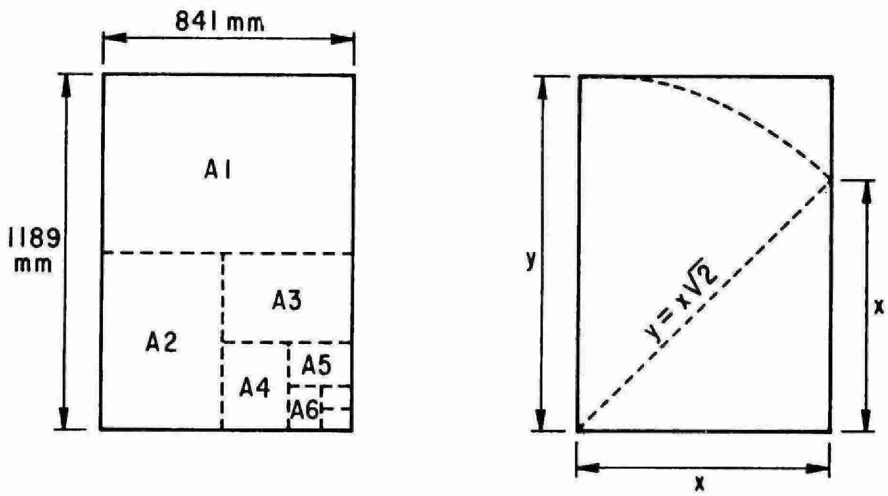
SECTION 2 - MAP AND PLAN SCALES, RATIOS AND PAPER SIZES

DRAWING PAPER SIZES

In the absence of a Canadian national standard for drawing paper sizes, MOE has adopted the ISO 'A' series, as described in CGSB 9-GP-100.

Basic Principles

The 'A' series of paper sizes is a rationally designed system based on a sheet having an area of 1 m^2 (841 x 1189 mm) from which all other sizes are derived by successively dividing it into two equal parts parallel to the shorter side. Consequently, the ratio of the areas of any two successive sheets is 2:1 and the ratio between the short side x and the long side y, of any sheet, is $1:\sqrt{2}$, i.e., the ratio between a side and the diagonal of a square.



SHEET SIZES

ISO Series 'A'

Trimmed sheet sizes are designated in Table 1 by 'A' followed by a number indicating the number of divisions that have been made. For example, sheet size A4 is produced from the basic AO sheet by four successive divisions. Sizes larger than AO may be designated by a prefix. Size 2AO is a sheet 1189 x 1682 mm and size 4AO is a sheet 1682 x 2378 mm.

Tolerances

The tolerances on the above dimensions will vary depending on the sheet size and the end use. Unless otherwise specified in the product standards, the following tolerances shall apply:

Sizes AO to A3 - -0; +2 mm

Sizes A4 to A10 - -0; +1 mm

TABLE 1 ISO SERIES 'A' PAPER SIZES

Designation	Dimensions, mm
A0	841 x 1189
A1	594 x 841
A2	420 x 594
A3	297 x 420
A4	210 x 297
A5	148 x 210
A6	105 x 148
A7	74 x 105
A8	52 x 74
A9	37 x 52
A10	26 x 37

LAYOUT AND IDENTIFICATION OF DRAWING SHEETS

General

All drawing sheets require certain basic information, such as title and scale, but additional information is generally desirable. The use of preprinted sheets enables inclusion of information which would be uneconomical if done by hand.

Sheets may be preprinted for general use or for a particular project.

Every sheet should include the following:

a) Border lines
b) Binding margin
c) Title block
d) Information panel.

Sheets may also contain:

e) Sheet grid reference systems
f) Camera alignment marks for microfilming
g) Marks to facilitate folding.

Borders

All drawing sheets should have a border on all four edges, that on the left-hand side being substantially wider than the others to provide a binding margin.

When borders are not provided, there is a risk of information being lost should the printing paper slip or be carelessly trimmed or the print damaged in use. Recommended border widths are shown in Table 2 below.

TABLE 2 DIMENSIONS OF DRAWING FRAME: WITH BINDING MARGIN

Drawing Sheet Size Designation	Nominal Width of Borders, mm On Top and Bottom	On LHS	On RHS	Dimensions of Rectangular Drawing Frame, mm
A0	20	40	16	801 x 1133
A1	14	28	12	566 x 801
A2	10	20	8	400 x 566
A3	7	20	6	283 x 394
A4	7	20	6	283 x 184

Note: Binding margin on A4 sheets is on a long edge, on other sheets it is on a short edge.

REFERENCE MATERIAL

(1) Metric Conversion:

Map and Plan
Scales, Ratios and Paper Sizes

- Published by the Interministerial Committee on National Standards and Specifications (Metric Committee), Ministry of Industry and Tourism, 900 Bay Street, Hearst Block, Queen's Park, Toronto, Ontario. M7A 1T4

(2) MTC Metric Office - Circular No. 7 (July 22, 1974)

- Published by Ministry of Transportation and Communications, Ontario

(3) Manual on Metric Building Drawing Practice

- Published by National Research Council of Canada(NRCC 15234)

(4) Metric Bulletin SI-4

- Published by Public Works Canada (See Appendix I).

Map and Plan Scales and Ratios Recommended for Use by Ontario Government

ISO RATIONAL RATIOS FOR ULTIMATE METRIC USE	DEVELOPED, PREFERRED AND TOLERATED SCALES AND RATIOS FOR USE IN IMMEDIATE FUTURE					PRESENTLY USED SCALES AND RATIOS TO BE PHASED OUT*
	PRESENTLY PREFERRED FOR USE IN BOTH INCH-FEET AND METRIC SYSTEM		CONVERSION FACTORS	FOR TOLERATED CONTINUING USE WHERE NECESSARY IN INCH-FEET SYSTEM		
1:1 000 000	1:1 000 000	NATIONAL TOPOGRAPHIC		1" = 25 MILES (1:1 584 000)	ALL ONTARIO ON 1 SHEET MINERAL MAP	
1:500 000	1:500 000	MAP SERIES OF ALL		1" = 16 MILES (1:1 013 760	INDEX MAPS ONTARIO IN 5 SHEETS IN ATLAS FORM, FOR MINERAL AND GEOLOGICAL MAPS	
1:200 000	1:250 000	CANADA	PHYSICAL CONVERSION NOT CONTEMPLATED IN FORSEEABLE FUTURE DUE TO COST, ETC. SPECIALIZED MAPS WILL REMAIN IN USE. FOR NON-SPECIALIZED USE, NTS SERIES AVAILABLE	1" = 8 MILES (1:506 880)	ONTARIO TERRITORIAL SERIES	
				1" = 4 MILES (1:253 440)	ONTARIO COUNTY AND ADMINISTRATIVE BOUNDARY MAPS, GEOLOGICAL COMPILATION MAPS	
1:100 000	1:125 000	NTS PARTS OF CENTRAL ONTARIO ONLY		1" = 2 MILES (1:126 720)	ONTARIO PROVINCIAL TOPOGRAPHIC SERIES, NORTHERN ONTARIO DISTRICTS	
1:50 000	1:50 000	NTS MAPS OF ALL SOUTHERN ONT. S OF 50° N.		1" = 1 MILE (1:63 360)	INDUSTRIAL MINERAL AND GEOLOGICAL MAPS, SOUTHERN AND CENTRAL ONTARIO.	
1:20 000	1:25 000	SOUTHERN ONT. ADJACENT TO LAKES ERIE & ONT. AND MAJOR POPULATION CENTRES ELSEWHERE			TOWNSHIP MAPS, SOUTHERN ONTARIO	
				1" = ½ MILE (1:31 680)	CADASTRAL TOWNSHIP PLANS OF SURFACE AND SUB-SURFACE RIGHTS	
				1" = ¼ MILE (1:15 840)	FOREST RESOURCES INVENTORY, SOUTHERN AND CENTRAL ONTARIO	
1:10 000	1:10 000	AREA STUDIES		1" = 1000' (1:12 000)	GEOLOGICAL MAPS, MAJOR MINING CAMPS	
1:5000	1:5000		-4%	1" = 400' (1:4800)	LOCATION AND BLOCK PLANS	ALL SCALES AND RATIOS NOT SHOWN IN COLUMN IMMEDIATELY TO LEFT SPECIFICALLY INCLUDING:
	1:2500	PRESENTLY USED IN PREFERENCE TO LITTLE USED 1:2000	0%	1" = 208.33' (1:2500)		
			-4%	1" = 200' (1:2400)		
1:2000	1:2000		+20%	1" = 200' (1:2400)		
	1:1250	SOME PRESENT USE. 1:1000 PREFERRED	0%	1" = 104.17' (1:1250)		
			-4%	1" = 100' (1:1200)		
1:1000	1:1000		+20%	1" = 100' (1:1200)		
1:500	1:500		-4%	1" = 40' (1:480)	SITE PLANS	1" = 20' (1:240)
1:200	1:200		-4%	1/16" = 1' (1:192)		1" = 10' (1:120)
1:100	1:100		-4%	1/8" = 1' (1:96)	DETAILED DRAWINGS OF LAYOUTS, COMPONENTS AND ASSEMBLIES FOR BUILDINGS OTHER STRUCTURES AND FACILITIES, MACHINERY AND EQUIPMENT	3/16" = 1' (1:64)
1:50	1:50		-4%	1/4" = 1' (1:48)		3/8" = 1' (1:32)
1:20	1:20		+20%	1/2" = 1' (1:24)		3/4" = 1' (1:16)
1:10	1:10		+20%	1" = 1' (1:12)		
			-20%	1½" = 1' (1:8)		
1:5	1:5		-20%	3" = 1' (1:4)		SHOULD BE PHASED OUT AS SOON AS POSSIBLE TO FACILITATE METRIC CONVERSION
1:2	1:2		0%	HALF SIZE (1:2)		
FULL SIZE	FULL SIZE		0%	FULL SIZE		

*Note: Wherever possible, switch directly to appropriate ratio scale in either of two extreme left-hand columns.

Ratio scales in the series 1,2,5 and multiples of same by any power of 10 to be used.

SECTION 3

DESIGN, SPECIFICATION AND UNITS OF EXPRESSION

SECTION 3 - DESIGN SPECIFICATION AND UNITS OF EXPRESSION

Design and specification shall be in accordance with (but not necessarily be restricted to) the requirements of the following documents:

1. The International System of Units (SI)
   CAN-3-001-01-73
   CSA Z234.2 - 1973

2. Canadian Metric Practice Guide
   CAN3-Z234.1-76
   (Replaces -
   CAN-3-001-02-73
   CSA Z234.1 - 1973)

3. Series of Standards for Metric Dimensional Co-ordination in Building
   CAN3-A31.M-75

4. Ontario Metric Practice Guide

5. Manual on Metric Building Drawing Practice
   (National Research Council Canada)

6. Metric Conversion & Map and Plan Scales, Ratios and Paper Sizes (Ontario)

7. Public Works Canada Metric Bulletin SI-6
   - "SI Units For Use in Design and Construction"

UNITS OF EXPRESSION FOR DESIGN AND CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE FOLLOWING DOCUMENTS

1. Wastewater Treatment

   - WPCF Manual of Practice
     MOP No. 6

     "Units of Expression for Wastewater Treatment"

2. Manual on Metric Building Drawing
   Practice - Part 9 (*pages 98-109 incl.)

   (*Also shown in Public Works Canada Metric Bulletin SI-6)

3. American Water Works Association

   Ontario Section

   Metric Conversion

   SI Units For Water Works Use
   - November 1976

SECTION 4

FACTORS AFFECTING CONVERSION

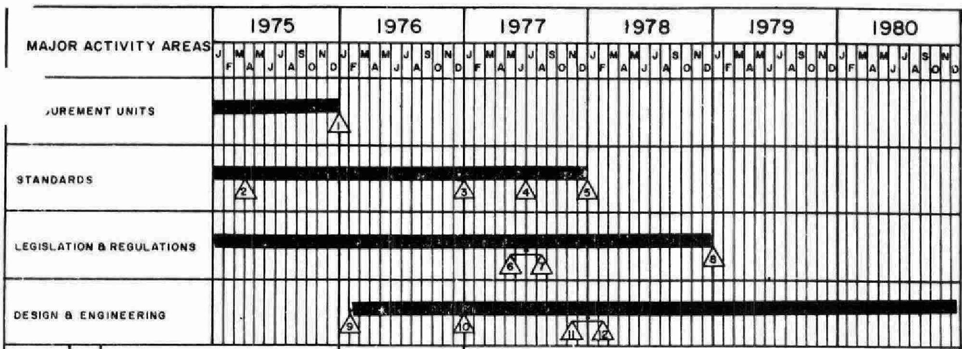
SECTION 4 - FACTORS AFFECTING CONVERSION

A guide for decision making on the conversion of Report/Design/Construction for Ministry (MOE) capital works projects has been shown (for purpose of facility only) as in insert on the "Bar Chart Sector 5.1 Construction (prepared by Sector Committee 5.1, Metric Commission of Canada).

It should be noted that Key Events, Items 1-24 inclusive are a part of the Sector 5.1 Bar Chart.

The content of the "insert" is a guide only and there may be other factors to be taken into account.

CONSIDERATIONS FOR METRICATION



LEGEND
△ KEY EVENT CRITICAL PATH
○ KEY EVENT WITH FLOAT
EARLIEST START — EARLIEST FINISH — LATEST FINISH

KEY EVENTS

1. Concensus of units & ratios
2. Standards conversion priorities established
3. 1st priority standards published
4. 2nd priority standards published
5. 3rd priority standards published
6. 1977 national building code & metric supplement published.
7. Revised federal provincial & municipal legislation enacted.
8. 1979 National building code published in metric
9. Start preliminary design for metric construction
10. Start update of drawing for metric construction
11. Initial metric tendering documents completed
12. Initial metric construction tendered (M-Day)

Status of Engineering	Report		Not started	Report in SI / Design and Construction in SI
			Partially completed	Complete Report in Imperial / Design and Construction in SI
			Completed	Design and Construction in SI
	Design in progress		Design not started	Design and Construction in SI
		Calculations	Not yet started	Carry out calcs. in SI
			Less than 50% complete	Convert results only to SI & continue in SI throughout
			More than 50% complete	Continue in Imperial and convert results only to SI
		Drawings & Specifications	Not yet started	Carry out in SI
			Less than 25% complete	Revise to conform to SI & continue in SI throughout
			More than 25% complete	Continue in Imperial throughout design and construction.
			Design completed	Construction in Imperial
Probable date of tendering			If before Sept. 30, 1977	Do not convert
			If after Sept. 30, 1977	Convert (if other considerations allow) abd defer tender to after M-day
Estimated cost of revisions			If less than ½% of capital cost	Convert (if other considerations allow)
			If more than ½% of capital cost	Do not convert (unless other considerations dictate)

Tendering in "metric" before Jan. 1/78 (M-day) is not permitted

Tendering in "Imperial" after June 30/78 is undesirable

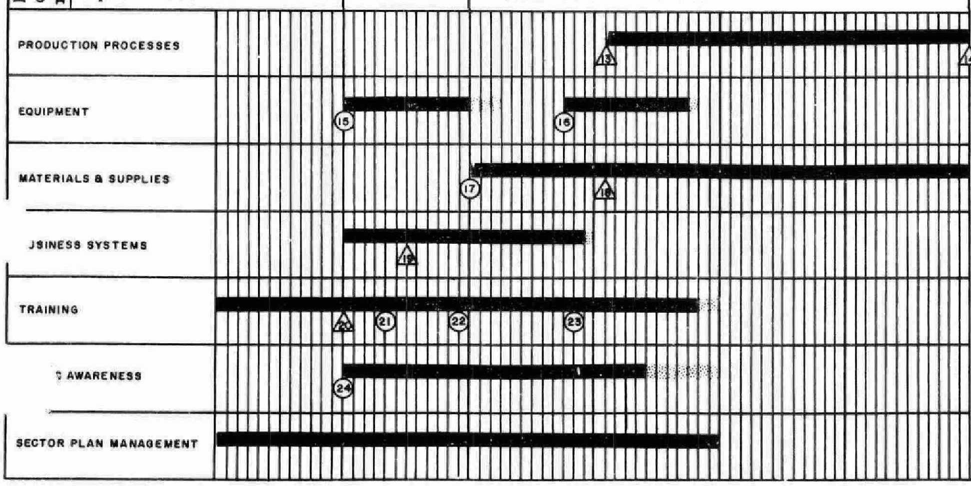
Decision to convert Engineering to "metric" depends on three major considerations:

(1) Status of Engineering
(2) Probable date of tendering
(3) Estimated cost of making revisions

e.g. (a) if the engineering is complete it is unlikely that conversion will be warranted,

(b) if the date of probable tendering is before Sept. 30/77 (i.e. M-day minus slack) there is no need to convert.

(c) If the cost of revising calculations, drawings, etc. is going to be greater than ½% (say) of capital construction cost, conversion is not warranted.



13. Start on-site metric construction.
14. All construction substantially metric.
15. Start acquisition of metric drafting equipment.
16. Start acquisition of metric on-site measuring equipment.
17. Start obtaining metric product literature.
18. Metric materials & components available.
19. Data prepared for metric estimates.
20. Start training professional designers & consultants.
21. Start training technicians & technologists.
22. Start training administrative personnel
23. Start training on-site personnel.
24. Start public awareness program

SECTION 5

EQUIPMENT

SECTION 5 - EQUIPMENT

METRIC CONVERSION GUIDELINES

Equipment (Sewage & Water Treatment; Pumping & Control)

1. The Metric System to be used will be the International System of Units (SI). Application of the S.I. system will conform to National Standard of Canada CAN-3-001-02 and CSAZ234.1 Metric practice guide (latest revision). The English language shall be used at all times.

2. Equipment Nameplates

   (1) It is preferred to have data inscribed on nameplates in SI units only.

   (2) If the data has been shown in Imperial units on the nameplate, it may remain on the equipment, but the corresponding data in SI units must be stamped either on the existing plate or on an additional plate affixed to the equipment.

3. Gauges and Scales
   (Indicating and Recording Meters)
   It is preferred that this equipment indicate and record in SI units only. However "dual" scales to indicate and record in both SI and Imperial units are acceptable.

4. Integrating Meter (Flow)
   Integrating meters are to measure and record in SI units only.

5. Connecting of Equipment (Metric and Imperial)
   Where both "Metric" and "Imperial" type equipment are to be installed under the same contract (i.e. piping, machinery, etc.), the Contractor must assure himself that the mating couplings, connectors, flanges, etc. are acceptable to the Engineer.

   If necessary (i.e. required by the Engineer) provide drawings for the Engineer's approval.

In all cases where metric equipment piping or other manufactured products supplied under a contract must mate with connecting non-metric equipment, piping or other manufactured products supplied under the same or any other contract, the contractor (for the given contract) must assure himself that mating with adjoining equipment is feasible and acceptable to the Engineer. The costs of supplying and installing all mating couplings, connectors and flanges are to be allowed for in the prices tendered by the Contractor for the work.

Note: short stub collars and/or slotted holes are not acceptable.

6. Specifications

Prepare the technical specifications in the contract documents to have Rating and Performance requirements in both Metric and Imperial Units, with the Imperial units shown in brackets.

The contract specifications are to state that Data and Performance Curves submitted by Equipment Suppliers are to be in SI units.

7. Fasteners

- Metric bolts and machine screws are preferred.
- All bolts and screws used on an assembly (pump, compressor, etc.) shall be Metric or Imperial and not a combination of both. The only exception may be at adapters.

8. Shop Drawings

Shop drawings submitted to the Engineer are to have dimensions required for installation shown in SI Units. If the equipment is available in Imperial Units only, then dimensions on the shop drawings are to be shown in SI Units, with Imperial Units shown in brackets.

APPENDIX I

- PUBLIC WORKS CANADA METRIC BULLETIN
  NOS. SI-1 TO SI-6 INCLUSIVE -

  SI-1,2 & 3 BY REFERENCE,
  SI-4,5 & 5 BY ENCLOSURE.

19.

Metric bulletin

SI-4

REALTY AND SURVEY

1. INTRODUCTION

1.1 The intention of this bulletin is to provide guidelines for the use of SI units within the realty and survey functions. While a particular circumstance may necessitate some deviation it is recommended that these guidelines be followed to the fullest extent possible.

1.2 DIMENSIONS SHOULD BE EXPRESSED TO THE MINIMUM NUMBER OF SIGNIFICANT FIGURES CONSISTENT WITH THE NEED TO PRESENT THEM WITH SUFFICIENT ACCURACY TO SERVE THEIR PURPOSE. Thus, the accuracy of a survey need not be reflected in the dimensions shown on a plan but may be explicitly recorded elsewhere.

1.3 IT SHOULD BE NOTED THAT IN THE CASE OF LEGAL OR CADASTRAL SURVEYS EACH PROVINCE WILL ISSUE DETAILS OF ITS OWN PARTICULAR METRIC CONVERSION REQUIREMENTS. It can be assumed that these will become nationally uniform as the conversion program develops.

1.4 As indicated in Bulletin SI-1, this is not an instruction to start applying the metric system in operational areas. Any such instruction will be issued by the head of the branch or function concerned.

2. MEASUREMENT UNITS.

2.1 LENGTH: The basic unit of length is the metre (m) together with its multiples and sub-multiples, i.e. the kilometre (km), the centimetre (cm) and the millimetre (mm).

In the realty and survey sectors, the submultiples of the metre will usually be expressed in decimals, e.g. 1 cm = 0.01 m and 1 mm = 0.001 m.

2.2 AREA: The basic unit of area is the square metre (m^2), together with its multiples the hectare (1 ha = 10 000 m^2) and the square kilometre (1 km^2 = 100 ha).

NEVER EXPRESS AN AREA AS "METRES SQUARE." THE CORRECT EXPRESSION IS "SQUARE METRES" e.g. there is a difference of 132 square metres between 12 square metres and 12 "metres square"!

2.3 VOLUME: The basic unit of volume is the cubic metre (m^3) together with its submultiple the litre (ℓ). The litre will only be used for small volumes ($1\ \ell = 0.001\ m^3$).

2.4 ANGLES: The existing units of angular measurement will not change, i.e. the degree, minute, and second.

3. ROUNDING OF NUMBERS.

3.1 The rounding of measurements follows the same principles in the metric system (SI) as in the customary or imperial system e.g.

7.2503	becomes 7.3	to one decimal place
7.3492	becomes 7.35	to two decimal places
7.3257	becomes 7.326	to three decimal places.

3.2 The final rounding of a number should be made in one step, e.g. 9.1948 correctly rounded in one step to two decimal places becomes 9.19 whereas an error occurs if the same number is rounded in two steps - 9.195 (first step) and 9.20 (second step).

3.3 When area, or volume, or cost is calculated by multiplication or division then rounding is always applied AFTER the calculation has been completed.

4. BUILDINGS.

4.1 The linear dimensions of buildings and spaces within buildings will be expressed in metres (m) TO TWO DECIMAL PLACES.

4.2 Areas of buildings and spaces within buildings will be expressed in square metres (m^2) TO ONE DECIMAL PLACE.

4.3 Volumes of buildings, reservoirs, large storage tanks, etc., will be expressed in cubic metres (m^3), normally TO THE NEAREST WHOLE CUBIC METRE.

4.4 Leasing or rental costs will be expressed in dollars per square metre per month or per annum.

5. LAND

5.1 For topographic surveys or similar purposes length will be expressed in metres to two decimal places. HOWEVER LENGTHS SHOULD BE ROUNDED TO A PRECISION CONSISTENT WITH THE NATURE OF THE SURVEY, e.g. in some circumstances lengths in excess of 500 m may be expressed to the nearest 0.1 m.

5.2 Areas will be expressed in hectares except for areas of less than 1 hectare which will be expressed in square metres. Areas over 10 000 hectares (100 km^2) will be expressed in square kilometres.

5.3 Areas should be expressed to no more than four significant figures. Areas under 100 m^2 should be rounded to not more than one decimal place.

5.5 Heights of permanent benchmarks have been soft converted to the equivalent three decimal places of a metre. Plates on benchmarks will be replaced in due course as the conversion program proceeds. FURTHER INFORMATION IS AVAILABLE FROM THE SURVEYOR GENERAL IN EACH PROVINCE.

5.6 Contour intervals should normally be chosen from among the following:

0.1 m, 0.2 m, 0.5 m, and mutiples of powers of 10 thereof, e.g. 1 m, 2 m, 5 m, 10 m, 20 m, 50 m, 100 m, etc.

5.7 Maps and survey drawings should conform to CGSB Standard 88GP-20M-75 which bases scale ratios on the 1-2-5 series. A SURVEY drawing scale should be selected from one of the following:

1:100, 1:200, 1:500, 1:1000, 1:2000, 1:5000, etc,

In some cases the existing 1:1250 survey scale and its multiples may have to be used for reasons beyond departmental control. The use of such scales can only be a local judgement at this point in time.

5.8 DUAL DIMENSIONS ARE NOT TO BE INDICATED ON DRAWINGS UNLESS THERE IS A COMPELLING REASON TO DO SO, e.g. to meet the requirements of a provincial or municipal authority during the early period of transition. If such is the case then the imperial equivalents will be shown in brackets immediately after the metric dimensions.

5.9 If existing survey plans are soft converted from imperial units to metric units of measurement then a list of the converted measurements with conversion factors should be added to the drawings together with a converted metric bar scale.

5.10 The dimensions of grids for spot levels, borings, and soundings should normally be expressed in whole metres.

5.11 The cost of land will be expressed in dollars per square metre ($/m^2$), dollars per hectare ($/ha) or dollars per square kilometre ($/km^2$).

6. HIGHWAYS AND ROAD SYSTEMS.

6.1 The following base documents are available for reference:

(a) "Manual of Geometric Design Standards for Canadian Roads and Streets" by RTAC (August 1976)

(b) "Highway Surveying in the Metric System" by Civil Engineering Branch, Public Works Canada.

7. COMMERCIAL ADVERTISING.

7.1 Real estate agents in other metric countries have rounded measurements to the following degrees of accuracy.

Office Space -

(a) Room dimensions to the nearest 0.1 m.
(b) Room areas to the nearest 1 m^2.
(c) Total building areas to the nearest 1 m^2, 5 m^2, or 10 m^2 depending on the size of the project.

Industrial Sites -

(a) Dimensions to the nearest 1 m.
(b) Areas to the nearest 10 m^2.

Small Properties -

Frontages and depths to the nearest 0.5 m.

It appears probable that custom will dictate similar advertising guidelines in Canada.

7.2 Measurements which imply a greater accuracy than used in the past should not be used, e,g. to advertise a property as situated 24.792 km from Pincher Creek or Matane is just as pointless as defining the distance as 15 miles 32 chains and 9 yards.

Similarly short distances to railway stations, post offices, etc. should be given in metres to the nearest 10 m, e.g. 350 m to railway station. Longer distances should be given in kilometres preferably to the nearest 0.5 km if less than 5 km and to the nearest 1 km if more than 5 km.

8. CONVERSION FACTORS FOR REALTY AND SURVEYING

8.1 Soft conversion from the existing imperial system to the metric system will be unavoidable until such time as all existing surveys, space inventories, deeds, and legal records have been converted. This type of conversion will generally be carried out on the basis of need, e.g. change of ownership, lease renewal, etc.

8.2 SIMPLIFIED CONVERSION TABLES.

LENGTH	1 km	=	0.621 371	miles	1 mile	=	1.609 344	km
		=	49.7097	chain	1 chain	=	20.1168	m
	1 m	=	1.093 61	yd	1 yd	=	0.9144	m
		=	3.280 84	ft	1 ft	=	0.3048	m
		=	39.3701	in	1 in	=	0.0254	m
AREA	1 km^2	=	0.386 102	$mile^2$	1 $mile^2$	=	2.589 99	km^2
		=	247.105	acre		=	258.999	ha
	1 ha	=	2.471 05	acre	1 acre	=	0.404 686	ha
	1 m^2	=	10.7639	ft^2		=	4046.86	m^2
					1 ft^2	=	0.092 903	m^2
VOLUME	1 m^3	=	1.307 95	yd^3	1 yd^3	=	0.764 555	m^3
		=	35.3147	ft^3	1 ft^3	=	0.028 317	m^3

COST	\$1000 per km^2	=	\$2590.00 per $mile^2$
	\$1000 per ha	=	\$ 404.69 per acre
	\$ 100 per m^2	=	\$ 9.29 per ft^2
	\$1000 per $mile^2$	=	\$ 386.10 per km^2
	\$ 100 per acre	=	\$ 247.10 per ha
	\$ 10 per ft^2	=	\$ 107.64 per m^2

9. Sector Committee 5.5 of the Metric Commission is concerned with metric conversion in the realty, surveying and land development sector of the national economy. The committee is composed of representatives of the following organizations:

Canadian Real Estate Association
Appraisal Institute of Canada
Canadian Institute of Surveying
Urban Development Institute of Canada
Town Planning Institute of Canada
Canadian Society of Landscape Architects
Community Planning Association of Canada
Public Works Canada

This committee has recommended that January 1, 1978, be nationally adopted as M-Day for this sector of the economy. It is expected that the Metric Commission will endorse this recommendation in the fall of 1976.

1976-07-15

PREFERRED SI DIMENSIONS IN BUILDINGS AND COMPONENTS

1. INTRODUCTION

1.1 Buildings are composed of many pieces, components and assemblies which must function together as an integrated system upon completion. Traditionally, these have been produced by many independently functioning manufacturers and have been coordinated only through the total building design. Custom-fitting on site has been relied upon to achieve coordination between different components and between these components and the building design. THIS WASTEFUL CUSTOM-FITTING CAN BE GREATLY REDUCED THROUGH PRE-COORDINATION. Once a system of design guidelines has been established any type of material or component can be incorporated in the design within AN UNRESTRICTIVE SYSTEM OF PRE-COORDINATION.

1.2 In most cases metric conversion implies changes in the traditional size of building products. THE CONSTRUCTION INDUSTRY, OF WHICH THE MANUFACTURER AND THE DESIGNER FORM IMPORTANT PARTS, IS TAKING ADVANTAGE OF METRIC CONVERSION TO RATIONALIZE AND COORDINATE A WIDE RANGE OF CONSTRUCTION PRODUCTS.

1.3 THE CONSTRUCTION INDUSTRY HAS ADOPTED 100 mm AS THE BASIC MODULE FOR SIZING CONSTRUCTION PROJECTS AND COMPONENTS. The careful selection of multimodules and submodules based on 100 mm creates a system of preferred dimensions for construction products and the buildings in which they are incorporated.

1.4 The number of possible multimodules and submodules is so great that it becomes necessary to reduce it to a practical range, providing both a reasonable choice to the designer and an economic range of products to the manufacturer.

1.5 A preferred dimension is one chosen in preference to others for specific reasons, e.g., coordination, standardization, simplification, flexibility, efficient use of materials, etc..

1.6 It should be noted that PROJECTS WHICH ARE DESIGNED TO PREFERRED METRIC DIMENSIONS CAN ACCEPT OR INCORPORATE BOTH DIMENSIONALLY COORDINATED AND TRADITIONAL COMPONENTS. However, the economic advantage lies with the former because wastage of time and material is much reduced.

The use of dimensionally coordinated metric components is NOT limited to dimensionally coordinated metric buildings.

1.7 THE APPLICATION OF PREFERRED METRIC DIMENSIONS IN DESIGN CANNOT BE DELAYED UNTIL SUCH TIME AS ALL BUILDING COMPONENTS BECOME AVAILABLE IN DIMENSIONALLY COORDINATED METRIC SIZES.

2. METRIC MATERIALS

2.1 The construction industry based its decision to adopt 1978-01-01 as construction M-Day on a number of premises, the most important of which is as follows: -

"THE MANUFACTURERS CONCERNED HAVE CONFIRMED THAT THEY WILL SUPPLY THOSE HARD CONVERTED METRIC MATERIALS AND COMPONENTS CONSIDERED TO BE ESSENTIAL TO A MEANINGFUL M-DAY."

These products will be manufactured to preferred dimensions.

2.2 The materials referred to form a minimal list which will undoubtedly include other products as M-Day approaches. M-DAY WILL BE FOLLOWED BY A TRANSITION PERIOD OF SOME 2 YEARS DURING WHICH TIME PROGRESSIVELY MORE HARD CONVERTED MATERIALS WILL BECOME AVAILABLE. The minimal list of essential materials is as follows: -

CONCRETE - composition, consistency, strength, volume.

MASONRY - blocks, bricks, tiles, mortars.

METALS - rebar, WWF shapes, angles, plate, extrusions, arch. metal

WOOD - panels

PARTITIONS - panels, doors, door frames

SHEETS - plywood, gypsum, fibreboard,asbestos, plastics, metals, glass.

WINDOWS - wood, metal, curtain-wall

FLOORS - resilient tiles, quarry tiles

CEILINGS - ceiling tiles, suspension systems

ELECTRICAL - recessed light fixtures

MECHANICAL - recessed ceiling grilles

NOTES a) Products which are not hard converted for the beginning of the transition period will be soft-converted.

b) The metric dimensions of lumber have yet to be determined by joint Canada-US consultation. See para. 5.3 for stud spacings.

3. PREFERRED SI DIMENSIONS FOR COMPONENTS

3.1 The system of preferred dimensions is logically based on brick, block, tile, and rigid sheet materials. These basic materials are dimensionally interdependent and relate to one another in a common panel size of 600 x 600 mm.

4. BRICK, BLOCK AND TILE

4.1 The metric "STANDARD" brick format is 200 x 100 x 67 mm including a 10 mm mortar joint. The dimension of 67 mm is a rounded dimension and is such that 9 courses equals 600 mm. The brick itself measures 190 x 90 x 57 mm.

4.2 The metric MODULAR brick format is 300 x 100 x 100 mm including a 10 mm joint. Availability of this brick will depend on market demand.

4.3 The metric modular block format, including a 10 mm mortar joint, is as follows: -

Length	Width	Height
200	100	100 mm
300	150	*200 mm
*400	200	300 mm
	250	
	300	

* Indicates the most commonly used dimensions.
It appears that industry will adopt the 2-core block in preference to the 1 or 3-core block.

4.4 The coordinating panel sizes for predominantly masonry buildings are listed as follows in order of preference:

Vertical mm	Horizontal mm		
	600 x n	200 x n	100 x n
600 x n	1	2	3
200 x n	2	2	3
*100 x n	3	3	3

where "n" is a whole number
*where "n" is an odd number horizontal joints will require an adjustment which may preclude the use of standard frames for wall openings.

4.5 The preferred horizontal and vertical dimensions for precast panels, including joints, are as follows:

1st preference: 600 x n
2nd preference: 200 x n or 300 x n
3rd preference: 100 x n

where "n" is a whole number.

4.6 The preferred nominal dimensions for clay, concrete, and ceramic tiles for floors and walls are as follows:

1st preference: 100 x n
2nd preference: 50 x n

where "n" is a whole number.

The thickness of tiles is selected from the following range:
3, 4, 5, 6, 8, 10, 12, 16, 20, 25, 40, 50 mm.

5. RIGID SHEET MATERIALS AND SUPPORTS

5.1 The most frequent demand for rigid sheet materials will be in the 1200 x 2400 mm size. This replaces the traditional "four by eight sheet.

The preferred dimensions for flat sheet materials are as follows:

(1) 1200 x 2400 or 3000 or 3600 mm

(2) 900 x 1800 or 2400 mm

(3) 600 x 1800 or 2400 or 3000 mm

The cover width of corrugated and profiled sheets is the same as for flat sheets with an added dimension for side laps.

5.2 The thickness of metric sheet materials has yet to be determined by industry and the authorities concerned.
Thickness is determined by such factors as strength, deflection, fire resistance, impermeability, inter-relationships, etc.

As an interim guide for drafting purposes the following table provides international standards for material thicknesses:

asbestos cement		3	4	5	6	8	10	12	16	20	25	mm		
fibreboard					6		10	12		20	25	40	50	mm
glass	2	3	4	5	6	8	10	12	16	20	25	mm		
gypsum					6		10	12	16		25	mm		
hardboard	2	3	4	5	6	8	10					mm		
particle board					6	8	10	12	16	20	25	mm		
plastic laminates		3			6		10	12	16	20	25	mm		
plywood		3	4	5	6	8	10	12	16	20	25	mm		
approximate in ins.	$\frac{1}{12}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2 ins.	

It is expected that Canadian products will adhere to the above within permissible tolerances.

5.3 There is a direct relationship between the widths of sheet materials and the spacing of studs, joists, beams, rafters and trusses. The spacing of such supporting members converts as follows:

Metric spacing in mm	300	400	600	1200	1800	2400
Customary spacing	12"	16"	2'.0"	4'.0"	6'.0"	8'.0"

6. CEILING AND FLOOR TILES

6.1 The preferred nominal dimensions for ceiling panels are as follows:

300 x 300 mm
600 x 300 mm
600 x 600 mm
1200 x 600 mm

6.2 The preferred nominal dimensions for resilient floor tiles are as follows:

300 x 300 mm
600 x 600 mm

7. PREFERRED DIMENSIONS IN PLANNING GRIDS

7.1 A controlling dimension is a dimension between controlling planes such as the distance between axes of columns, floor-to-floor heights, etc.

7.2 Horizontal controlling dimensions should preferably be multiples of:

200 mm up to 3600 mm
300 mm up to 3600 mm
600 mm above 3600 mm

Notes a) The 200 or 600 mm multimodule should be selected for masonry buildings.

b) These preferences do not restrict the use of the 200 or 300 mm multimodules above the 3600 mm dimension.

7.3 Vertical controlling dimensions for floor-to-floor heights should preferably be multiples of:

200 mm or 100 mm from 2400 mm up to 3000 mm
200 mm or 300 mm from 3000 mm up to 4800 mm
600 mm above 4800 mm

Notes: a) The 200 or 600 multimodule should be selected for masonry buildings.

b) Floor-to-floor heights below 2600 mm are not recommended for other than basements, corridors, garages, agricultural buildings, etc.

7.4 Vertical controlling dimensions for floor-to-ceiling heights should preferably be multiples of:

100 mm from 2100 mm up to 2700 mm
200 mm or 300 mm from 2700 mm up to 3600 mm
600 mm above 3600 mm

Notes: a) These preferences do not restrict the use of the 200 or 300 mm multimodules above the 3600 mm dimension.

b) Floor-to-ceiling heights below 2400 mm are not recommended for other than basements, corridors, garages, agricultural buildings etc..

8. WALL OPENINGS

8.1 Widths of rough wall openings should be selected from the following range of dimensions:

600, 800, *900, 1000, 1200, 1400, *1500, 1600, 1800, 2000, *2100, 2400 mm

* Denotes dimensions not particularly suited to masonry construction.

8.2 Heights to the top of rough wall openings measured from floor level should be selected from the following range of dimensions:

2000, *2100, 2200, 2400, 2600 *2700 mm

* Denotes dimensions not particularly suited to masonry construction.

8.3 Heights from floor level to the bottom of the rough window opening should be selected from the following range of dimensions:

*300, 400, 600, 800, *900, 1000, 1200 mm

* Denotes dimensions not particularly suited to masonry construction.

Note:

Heights for window-sills may be any multiple of 100 mm to suit functional requirements. 800 mm is a suitable height for a window by a desk and 1000 mm for a window above a kitchen counter or laboratory bench.

9. PRODUCT LITERATURE

9.1 The construction industry expects that distribution of manufacturers' technical data on metric products, based on the foregoing preferred dimensions, will begin in January 1977.

10. REFERENCES:

Manual on Metric Building Drawing Practice - - - - - - - DPW/CMHC/NRC

Metric Practice Guide - CAN-3-Z234.1-76 - - - - - - - CSA

* Standards for Metric Dimensional Coordination - CAN-3-A31.M-75 - - CSA

SI Bulletins - - - - - - - - - - - - DPW

* This document bases preferred dimensions on the use of the metric modular brick. This brick is unlikely to be in general use in the foreseeable future.

1976-08-20 RFW

Metric bulletin

SI-6

SI UNITS FOR USE IN DESIGN AND CONSTRUCTION

1. INTRODUCTION

1.1 The 1977 edition of the National Building Code will be published simultaneously in both official languages in July 1977. This edition of the code will use the customary or imperial system of measurement and will not provide any metric equivalents.

1.2 Metric values for all dimensions referred to in the code will be provided in a separate pamphlet giving either soft converted metric equivalents or hard metric values as appropriate. This metric pamphlet will be automatically distributed with each copy of the code.

1.3 During the transition period, Metric Products Bulletins will be issued at intervals to accommodate the acceptance of metric products within code requirements.

1.4 Preliminary copies of the 1977 edition of the National Building Code will be made available to Federal and Provincial design and construction agencies in January 1977. Preliminary copies of the metric pamphlet will be issued in April 1977.

1.5 The 1979 edition of the National Building Code will be produced as a wholly metric code.

1.6 Those metric (SI) units used in design and construction and referred to in codes, standards, and practice guides are shown hereafter in the following sequence:

1976-09-24

...S FOR ARCHITECTURAL AND ENGINEERING

Quantity	SI Unit Symbol	Recommended Unit Symbol	Recommended Unit Name	Typical Application	Remarks
Length	m	m	metre	Levels, over-all dimensions; spans, column heights, etc.	
		cm	centimetre	Snowfall, glass pane dimensions.	
		mm	millimetre	Spans; dimensions in buildings; depth and width of sections; displacement, settlement, deflection, elongation; slump of concrete, size of aggregate; radius of gyration; eccentricity, detailed dimensions generally, rain fall.	
		μm	micrometre	Thickness of coatings (paint, galvanizing, etc.) thin sheet materials size of fine aggregates.	
Area	m^2	m^2	square metre	Small land areas; area of cross-section of earthworks.	
		cm^2	square centimetre	Area in special applications.	
		mm^2	square millimetre	Area of cross-section of structural and other sections, bars, etc.	
Volume, Capacity	m^3	m^3	cubic metre	Volume, capacity (large quantities); volume of earthwork, excavation, concrete, timber, fluids, etc.	$1\ m^3 = 10^3 \ell$
		mm^3	cubic millimetre	Volume, capacity (small quantities).	
		ℓ	litre	Volume of fluids and containers for fluids only.	$1\ \ell = 1\ dm^3$ $1\ ml = 10^3\ mm^3$
Modulus of section	m^3	cm^3	centimetre to third power	Geometric properties of structural section.	first moment of area
		mm^3	millimetre to third power		
Moment of inertia	m^4	cm^4	centimetre to fourth power	Geometric properties of structural sections.	second moment of area
		mm^4	millimetre to fourth power		
Time	s	s	second	Time used in methods of test; unit used for coherent derived units involving time.	
		h	hour	Time used in methods of test.	
		d	day		
		a	year		
Temperature	K	°C	degree Celsius		Temperature value is normally measured in °C. °C ≙ 273.15 K

Quantity	SI Unit Symbol	Recommended Unit Symbol	Recommended Unit Name	Typical Application	Remarks
Temperature interval	K	°C	degree Celsius	Calculations involving thermal expansion; temperature value and temperature interval in test methods, etc.	1 K = 1°C
Base Temperature "Degree Day"				18°C used for calculation of degree-day tables. (See NRC/DBR publication BR Note 98: Converting Heating Degree-Days From Below 65°F to below 18°C by D.W. Boyd.)	
Velocity, Speed	m/s	m/s	metre per second	Velocity and speed in general; velocity of fluids.	1 m/s = 3.6 km/h
		km/h	kilometre per hour	Wind speed.	
Mass	kg	kg	kilogram	Mass of quantities of materials in general.	
		t	tonne	Mass of large quantities of structural steel, reinforcement, concrete, ratings of lifting equipment.	1 t = 10^3 kg
		g	gram	Mass of samples of material for testing.	
Mass per unit length	kg/m	kg/m	kilogram per metre	Mass per unit length of sections, bars, and similar items of uniform cross-section.	also known as "linear density"
		g/m	gram per metre	Mass per unit length of wire and similar material of uniform cross-section.	
Mass per unit area	kg/m^2	kg/m^2	kilogram per square metre	Mass per unit area of slabs, plates, and similar items of uniform thickness or depth; rating for load-carrying capacities of floors (for display on notices, not for use in calculations).	also known as "area density"
		g/m^2	gram per square metre	Mass per unit area of thin sheet materials, coatings, etc.	
Density Concentration	kg/m^3	kg/m^3	kilogram per cubic metre	Density of materials in general; mass per unit volume of materials in a concrete mix.	also known as "mass per unit volume"
Force	N	kN	kilonewton	Forces in columns, piles, ties, pre-stressing tendons, etc; concentrated forces, axial forces; reactions, shear force, gravitational force (load).	
Force per unit length	N/m	kN/m	kilonewton per metre	Transverse force (load) per unit length on a beam, columns, etc; force distributed in a linear direction.	

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Force per unit area	N/m^2	kN/m^2	kilonewton per square metre	Uniformly distributed loads on floors, under footings, wind load, snow load, dead and live load, etc.	
Moment of force or torque	N·m	kN·m	kilonewton metre	Bending moment; torsional moment; overturning moment; tightening torque for high-strength bolts, etc.	
Pressure	Pa	kPa	kilopascal	Pressure in fluids and gases	$1\ Pa = 1\ N/m^2$
Stress modulus of elasticity	Pa	MPa	megapascal	Modulus of elasticity; stress (ultimate, proof, yield, permissible, calculated, etc.) in structural material.	$1\ MPa = 1\ N/mm^2 = 1\ MN/m^2$

UNITS FOR USE IN ACOUSTICAL ENGINEERING

Frequency	Hz	kHz MHz GHz	kilohertz megahertz gigahertz		1 Hz = 1 revolution per second
Sound power	W	W pW	watt picowatt	1 pW is the reference quantity for sound power level, i.e., Sound power level, L = $= 10 \log_{10} \frac{\text{actual power (W)}}{10^{-12}\ (W)}$ dB	
Sound intensity	W/m^2	W/m^2 pW/m^2	watt per square metre picowatt per square metre	$1\ pW/m^2$ is the reference quantity for sound intensity level, i.e., Sound intensity level L_I = $= 10 \log_{10} \frac{\text{actual intensity } (W/m^2)}{10^{-12}\ (W/m^2)}$ dB	
Sound pressure	Pa	μPa	micropascal	20 μPa is the reference quantity for sound pressure level, i.e., Sound pressure level L_p = $= 20 \log_{10} \frac{\text{actual pressure (Pa)}}{20 \times 10^{-6}\ (Pa)}$ dB	

Quantity	SI Unit Symbol	Recommended Unit Symbol	Recommended Unit Name	Typical Application	Remarks
Length	m	m	metre	Trenches, curbs, fences, timber lengths, pipes and conduits; length of building materials generally.	
		mm	millimetre	Timber cross-sections; thicknesses, diameters, gauges of sheet metal, fasteners; all building product dimensions.	
Area	m^2	m^2	square metre	Site clearing, paving, brickwork, roofing, glass areas, wall and floor finishes, surface treatment, paintwork, plastering, membranes, lining materials, insulation, reinforcing mesh, formwork; areas of all building components.	Replaces sq ft, sq yd, square. Brickwork to be specified by wall area × wall thickness.
		cm^2	square centimetre	Small areas in special applications.	
		mm^2	square millimetre	Small areas in special applications.	
Volume	m^3	m^3	cubic metre	Excavation, filling, waste removal; supply of concrete, sand, all bulk materials supplied by volume and large quantities of timber.	Replaces cu ft and cu yd $1\ m^3 = 10^3\ \ell$
		ℓ	litre	Liquid materials and containers for same.	
Mass	kg	kg	kilogram	All bulk materials supplied by mass.	
		t	tonne	Large masses, aggregates, structural steel and reinforcement.	$1\ t = 10^3\ kg$
Time	s	h	hour	All calculations involving time; labour time, plant hire, testing periods.	$1\ h = 3.6 \times 10^3\ s$
Stress	Pa	MPa	megapascal	Concrete strength grade, steel strength grades.	

UNITS FOR USE IN LAND SURVEYING

Quantity	SI Unit Symbol	Recommended Unit Symbol	Recommended Unit Name	Typical Application	Remarks
Length	m	m	metre	Boundary and cadastral surveys; survey plans; heights, geodetic surveying; contours.	
		km	kilometre	Geographical and statistical purposes.	
		mm	millimetre	Measurements carried out on maps, plans and photographs.	
Area	m^2	m^2	square metre	Small land areas, area in general.	
		ha	hectare	Areas on boundary and cadastral survey plans; other survey plans.	1 ha = 10^4 m^2 1 km^2 = 10^2 ha "Concession" will probably be retained as a legal term, expressed in h
		mm^2	square millimetre	Measurement carried out on maps, plans and photographs.	
Volume	m^3	m^3	cubic metre	General applications.	1 m^3 = 10^3 ℓ
		ℓ	litre	Small liquid volumes	
Plane angle	rad	° ' "	degree minute second	Bearings shown on boundary and cadastral survey plans; geodetic surveying.	$1° = \frac{\pi}{180}$ rad
Temperature	K	°C	degree Celsius		Temperature interval 1°C = 1 K

UNITS FOR USE IN ILLUMINATION ENGINEERING

Luminous intensity	cd	cd	candela	Used in the determination of illumination levels and lighting layouts.	
Luminous flux	lm	lm	lumen		
Illuminance	lx	lx	lux	Replaces foot candle (lm/ft^2) and phot (1 ph = 10^4 lx).	
Luminance	cd/m^2	cd/m^2	candela per square metre	Replaces stilb (1 sb = 10^4 cd/m^2).	

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Length	m	m	metre	Pipe and channel lengths, storage depths of reservoirs, aquifer thickness, drawdown in wells, height of potentiometric head, hydraulic head, piezometric head, level meters, staff gauges.	
		km	kilometre	Longer pipes and channels.	
		mm	millimetre	Pipe diameters, radius of ground water wells, height of capillary rise, depth of irrigation watering, rainfall precipitation, evaporation.	
Area measurement	m^2	m^2	square metre	Cross-sectional area of channels and longer diameter pipes, surface areas of reservoirs, smaller catchment areas.	1 ha = 10^4 m^2
		cm^2	square centimetre	Small areas in special applications.	
		mm^2	square millimetre	Cross-sectional area of small diameter pipes.	1 m^2 = 10^6 mm^2
		km^2	square kilometre	Large catchment areas.	1 km^2 = 10^2 ha
		ha	hectare	Land areas, irrigation areas.	
Volume	m^3	m^3	cubic metre	Water distribution, irrigation diversions, sewage, storage capacity, underground basins. As far as possible the cubic metre should be the preferred unit of volume for engineering and scientific purposes. The litre and its multiples and submultiples may be used for domestic and industrial supplies where an interface with the public exists.	1 m^3 = 1000 ℓ
		ℓ	litre	Domestic supply, domestic billing. All recommended units of volume can be expressed 'per day' (3/d), 'per year' (3/a), etc., if the context implies the total volume delivered over the particular period.	
Velocity	m/s	m/s	metre per second	River or stream flow velocity, pipe flow velocity.	
Instantaneous volumetric flow rates	m^3/s	m^3/s	cubic metre per second	Flow in pipes, channel flow, flow in rivers and streams, sludge flow, irrigation spray demand. Attention is drawn to the remarks opposite 'Volume'.	
		ℓ/s	litre per second		
		ml/s	millilitre per second	Lesser flow rates.	
Pressure	Pa	kPa MPa	kilopascal megapascal	Hydraulic head is measured in metres.	1 Pa = 1 N/m^2
Work	J	kJ MJ	kilojoule megajoule	Work done, energy available, quantity of heat. The kilowatt hour is a unit for the measurement of electrical energy only.	1 MJ = 0.277 778 k[illegible]

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Power	W	kW	kilowatt	Heat flow meters, motor powers, rate of doing work.	
Sewage contribution			cubic metre per person per day		
Concentrations		mg/ℓ	milligram per litre		

UNITS FOR MECHANICAL ENGINEERING

Quantity	SI Unit Symbol	Symbol	Name	Typical Application	Remarks
Mass	kg	kg t	kilogram tonne	Masses of structures, machines, etc. Generally the kilogram is to be used in calculations, specifications, etc. However, masses of the order of 10 kg and greater may conveniently be expressed in tonnes.	$1\ t = 10^3\ kg$
Volume	m^3	m^3 ℓ	cubic metre litre	Volumes of fuel oil tanks, water tanks and containers. Gas volumes. Generally the cubic metre is to be used in calculations, specifications, etc. The litre will only be used where an interface with the public arises, or when the volumes concerned are less than 1 m^3.	$1\ m^3 = 10^3$ ℓ
Mass per unit length	kg/m	kg/m	kilogram per metre	Evaluation of the masses of structural sections, cables, etc.	known also as "linear density"
Mass per unit area	kg/m^2	kg/m^2	kilogram per square metre	Evaluation of the masses of walls, floors, glass, plates, sheets, etc.	known also as "area density"
Density	kg/m^3	kg/m^3	kilogram per cubic metre	Evaluation of the masses of structures and materials.	known also as "mass per unit volume"
Mass per unit time	kg/s	kg/s t/h	kilogram per second tonne per hour	Rate of transport of material on conveyors. Rate of gas flows in special cases.	
Velocity	m/s	m/s km/h	metre per second kilometre per hour	Calculations involving rectilinar motion, wind velocities.	1 m/s = 3.6 km/h
Speed	m/s	km/h	kilometre per hour	The speed of cars and vehicles of all descriptions.	1 m/s = 3.6 km/h
Acceleration	m/s^2	m/s^2	metre per second squared	Kinematics and calculation of dynamic forces.	Standard gravitational acceleration g = 9.806 65 m/s²
Force	N	kN	kilonewton	Calculations involving dynamic forces, forces in cables.	$1\ N = 1\ kg \cdot m/s^2$
Pressure	Pa	kPa MPa	kilopascal megapascal	Bearing pressures, stresses in materials, vapour pressure.	$1\ Pa = 1\ N/m^2$

UNITS FOR USE IN MECHANICAL ENGINEERING (Cont'd)

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Momentum	kg·m/s	kg·m/s	kilogram metre per second	Evaluation of impact and dynamic forces	
Angular velocity	rad/s	r/s r/min	revolutions per second revolutions per minute	Calculations involving rotational motion.	The revolution per second will be used for describing machinery speed
Torque	N·m	N·m kN·m MN·m	newton metre kilonewton metre meganewton metre	Calculations involving rotational motion, bending moments in structural sections, torque in engine drive shafts, axles, etc.	Also known as "moment of force."
Moment of inertia	$kg{\cdot}m^2$	$kg{\cdot}m^2$	kilogram metre to second power	Rotational dynamics. Evaluation of the restraining forces required for propellers, windmills, etc.	
Dynamic viscosity	Pa·s	Pa·s	pascal second	Shear stresses in fluids.	The centipoise (cP) = 10^{-3} Pa·s will not be used.
Kinematic viscosity	m^2/s	mm^2/s	square millimetre per second	Computing Reynolds number.	The centistoke (cSt) = 10^{-6} m^2/s will not be used.
Volume flow rate	m^3/s	m^3/s ℓ/s m^3/s ℓ/s	cubic metre per second litre per second cubic metre per second litre per second	Flow (general) Flow (general) Flows in pipes, air conditioning ducts and the like. Fluids only	Comparatively high rate Comparatively low rate fluids only.
Concentration	kg/m^3	$\mu g/m^3$	microgram per cubic metre	Pollution control	
Enthalpy Latent heat Sensible heat	J	J kJ MJ	joule kilojoule megajoule	Thermal energy calculations. Mechanical and electrical energy.	
Work, Energy		kW·h	kilowatt hour	Electrical metering purposes only.	1 kW·h = 3.6 MJ
Power	W	W mW kW MW	watt milliwatt kilowatt megawatt	Power input, output, rating, etc., of heavy power plant. Power in general (mechanical, electrical, thermal, etc.); input, output rating, etc., of motors, engines, heating and ventilating plant and other equipment in general. Heat flow rate through walls, windows, etc.	

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
emperature	K	K	kelvin	Expression of thermodynamic temperature, calculations involving units of temperature.	°C ≘ 273.15 K
		°C	degree Celsius	Most commonly used temperature scale. Will be used in meteorology, engineering and all facets of building and construction.	
Temperature interval	K	°C	degree Celsius	Heat transfer calculations.	1K = 1°C
Coefficient of linear expansion	1/K	1/°C	reciprocal degree Celsius	Expansion of material subjected to a change in temperature; expressed as a ratio per degree Celsius.	
Heat flux density, intensity of heat flow	W/m^2	W/m^2	watt per square metre	Flow of heat through buildings, walls and other heat transfer surfaces.	
		kW/m^2	kilowatt per square metre	Transmission calculations.	
Thermal conductivity, heat transfer coefficient	W/m·K	W/m·°C	watt per metre degree Celsius	Estimation of thermal behaviour of materials and systems. Heat transmission calculations.	k-value
Thermal conductance	$W/m^2 \cdot K$	$W/m^2 °C$	watt per square metre degree Celsius	Heat transmission calculations.	U-value
Thermal resistivity	m·K/W	m·°C/W	metre degree Celsius per watt	Heat transmission calculations.	
Thermal resistance	$m^2 \cdot K/W$	$m^2 \cdot °C/W$	square metre degree Celsius per watt	Heat transmission calculations.	R-value
Heat capacity	J/K	J/°C	joule per degree Celsius	Thermal behaviour of materials. Heat transmission calculations.	
Specific heat capacity	J/kg·K	kJ/kg·°C	kilojoule per kilogram degree Celsius	Heat transmission calculations.	
Specific energy	J/kg	kJ/kg	kilojoule per kilogram	Heat and energy contained in materials. Calorific values of fuels.	
		MJ/kg	megajoule per kilogram		
Specific sensible heat. Specific latent heat				Psychrometric calculations	
Specific volume	m^3/kg	m^3/kg	cubic metre per kilogram	Calculations involving fluids.	
Moisture content	kg/kg	kg/kg	kilogram per kilogram	Psychrometric calculations.	
		g/kg	gram per kilogram		

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
ermeability		ng/Pa·s·m	nanogram per pascal second metre	Water vapour transmission	
ermeance		ng/Pa·s·m^2	nanogram per pascal second metre squared	Water vapour transmission through walls, etc.	

UNITS FOR USE IN ELECTRICAL ENGINEERING

Electric current (intensity of electric current)	A	kA A mA μA	kiloampere ampere milliampere microampere	Maintenance rating of an electrical installation. Leakage current.	
Electric change. Quantity of electricity	C	kC C μC nC pC	kilocoulomb coulomb microcoulomb nanocoulomb picocoulomb	The voltage on a unit with capacitive type characteristics may be related to the amount of charge present (e.g., electrostatic precipitators). Storage battery capacities.	
Electric potential. Potential difference. Electromotive force	V	MV kV mV μV	megavolt kilovolt millivolt microvolt	The electric field strength gives the potential gradient at points in space. This may be used to calculate or test electrical parameters such as dielectric strength.	
Electric field strength	V/m	MV/m kV/m mV/m μV/m	megavolt per metre kilovolt per metre millivolt per metre microvolt per metre	The electric field strength gives the potential gradient at points in space. This may be used to calculate or test electrical parameters such as dielectric strength.	
Capacitance	F	F mF μF nF pF	farad millifarad microfarad nanofarad picofarad	Electronic components. Electrical design and performance calculators.	
Current density	A/m^2	A/m^2 kA/m^2	ampere per square metre kiloampere per square metre	Design of cross-sectional area of electrical conductor.	
Magnetic field strength	A/m	A/m kA/m	ampere per metre kiloampere per metre	Magnetic field strength used in calculation of magnetic circuitry such as transformers, magnetic amplifiers and general cores.	
Magnetomotive rce. netic tential difference	A	kA A mA	kiloampere ampere milliampere	Used in the calculations involved in magnetic circuits.	

Quantity	SI Unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Flux of magnetic induction. Magnetic flux	Wb	mWb	milliweber	Used in the calculations involved in magnetic circuits.	
Magnetic flux density. Magnetic induction	T	T mT μT nT	tesla millitesla microtesla nanotesla	Used in the calculations involved in magnetic circuits.	
Magnetic vector potential	Wb/m	kWb/m	kiloweber per metre	Used in the calculations involved in magnetic circuits.	
Self-inductance. Mutual inductance	H	H mH μH nH pH	henry millihenry microhenry nanohenry picohenry	Used in analysis and calculations involving transformers.	
Permeability	H/m	H/m μH/m nH/m	henry per metre microhenry per metre nanohenry per metre	Permeability gives the relationship between the magnetic flux density and the magnetic field strength.	
Resistance	Ω	GΩ MΩ kΩ Ω mΩ	gigaohm megohm kilohm ohm milliohm	The design of electrical devices with infinite resistance such as motors, generators, heaters.	
Conductance, Admittance, Susceptance	S	MS kS S mS μS	megasiemens kilosiemens siemens millisiemens microsiemens	The design of electrical devices with finite resistance such as motors, generators, heaters.	
Resistivity	Ω·m	GΩ·m MΩ·m kΩ·m Ω·m mΩ·m μΩ·m nΩ·m	gigaohm metre megohm metre kilohm metre ohm metre milliohm metre microohm metre nanoohm metre	The design of electrical devices with finite resistance such as motors, generators, heaters.	
Conductivity	S/m	MS/m kS/m S/m μS/m	megasiemens per metre kilosiemens per metre siemens per metre microsiemens per metre	The design of electrical devices with finite resistance such as motors, generators, heaters. A parameter for measuring water quality.	
Reluctance	H^{-1}	H^{-1}	reciprocal henry	Design of motors and generators.	
Permeance	H	H	henry		

Quantity	SI unit Symbol	Recommended Unit		Typical Application	Remarks
		Symbol	Name		
Impedance, Reactance	Ω	MΩ kΩ mΩ	megohom kilohm milliohm	The design of electrical motors, generators and transmission lines.	
Active Power	W	TW GW MW kW W mW μW	terawatt gigawatt megawatt kilowatt watt milliwatt microwatt	The useful power in an electrical circuit.	
Apparent Power	V·A	TV·A GV·A MV·A kV·A V·A mV·A μV·A	teravolt ampere gigavolt ampere megavolt ampere kilovolt ampere volt ampere millivolt ampere microvolt ampere	The total volt-amperes in an electrical circuit	Reactive power is expressed in vars (var).

CONSTANTS FOR GENERAL USE

Name	Symbol	Value	Unit
Standard atmosphere pressure	P_o	100.0	kPa
Absolute zero (temperature)	T	-273.15°C	
Standard acceleration due to gravity	g	9.806 65	m/s^2
Velocity of sound in air (P_o, 20°C, 50%, R.H.)	M	344	m/s
Specific volume of perfect gas at STP	V_o	22.414	m^3/kmol
Characteristic gas constant for air	R_a	287.045	J/kg·K
Characteristic gas constant for water vapour	R_v	461.52	J/kg·K
Natural logarithms	e	2.718 281 828 5	
	π	3.141 529 653 6	